CERES Meeting Objectives

1. Review status of CERES Instruments and Data Products:

- Status of CERES/NASA/EOS/Senior Reviews and CERES on NPP and NPOESS
- **Terra and Aqua SW/LW/TOTAL channel calibration for Edition 3**; CERES FM5, FM6 Update
- **Edition 3 cloud algorithm development and validation**
- CRS Edition 2 Validation and Edition 3 Plans
- **Extending SRBAVG, ISCCP-like-GEO and SYN/AVG/ZAVG to December 2007: Overcoming MTSAT Calibration Challenges.**
- ISCCP-like MODIS & GEO Data Products
- **On Making CERES Level-3 Edition 3 Data Products More User Friendly**
- **Towards Early Release of Edition 3 Quality Level-3 TOA Fluxes Through End of 2008**
- Data Management Team Update: Terra/Aqua/NPP; Plans to Optimize CERES Processing
- GEOS-5 Update
- Atmospheric Sciences Data Center (ASDC) Update
- SCOOL Update & S'COOL Rover observations (see overpass times on p. 4).

2. Invited Science Presentations. Each presentation is 45 min including time for questions.

3. CERES Science Reports. Each report is 20 min including time for questions.

State of CERES/NASA/EOS/Senior Reviews/ CERES on NPP and NPOESS/Decadal Survey Missions

Norman G. Loeb, NASA LaRC

CERES Science Team Meeting November 3, 2009, Fort Collins, CO

NASA Earth Science

- NASA Administrator is Charles Bolden, Jr.
- AA for Space and Earth Science is Ed Weiler.
- Head of Earth Science is Mike Freilich.
- Jack Kaye is Associate Director for R&A.
- David Considine is NASA HQ Modeling lead and CERES Program Scientist.
- Hal Maring remains Radiation Sciences program lead.
- Steve Volz is the Earth Science Deputy for Missions.
- Richard Slonaker is new Program Executive, NASA-HQ.

CERES Team Leads

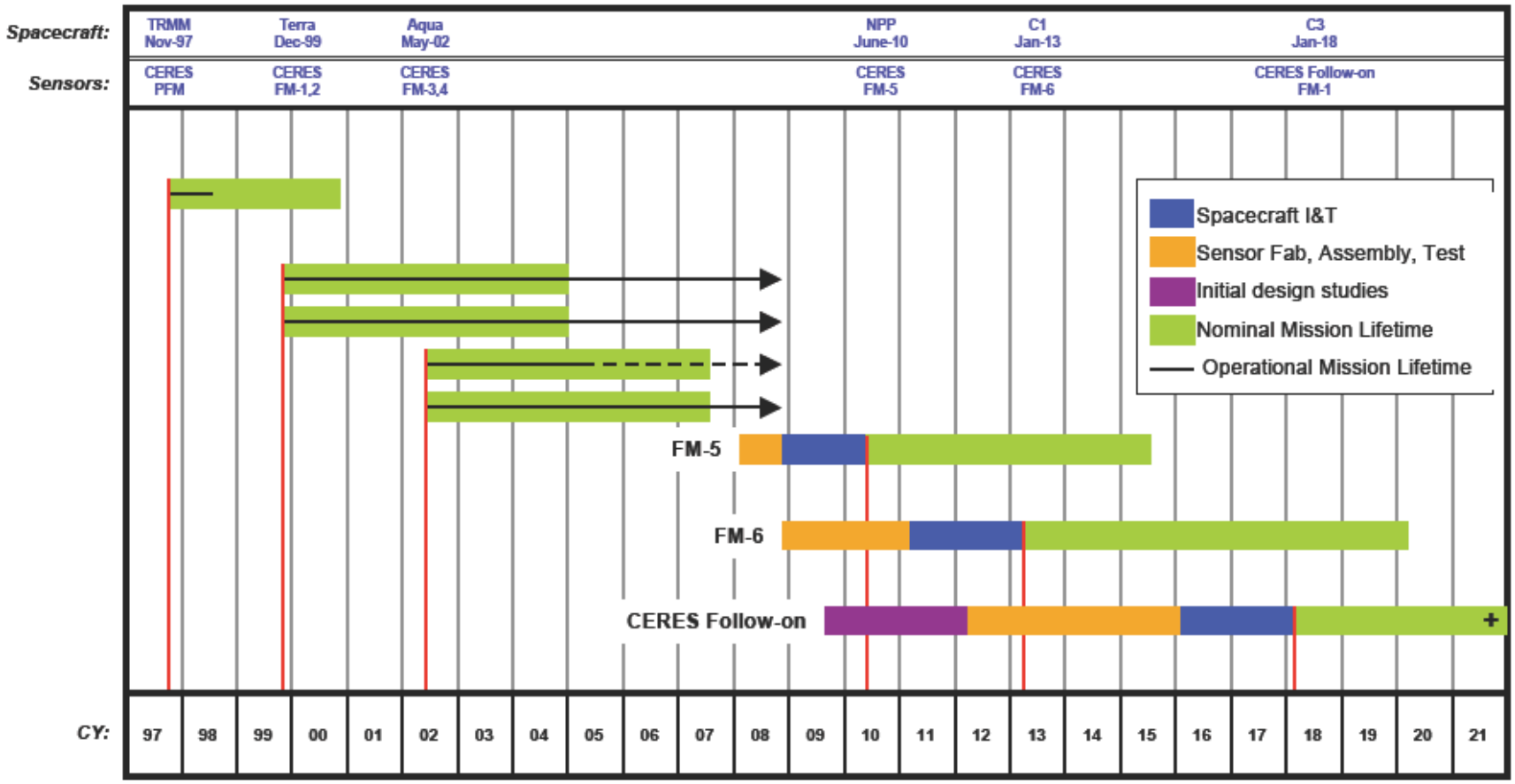
- Principal Investigator: Norman Loeb
- Project Scientist: Kory Priestley

CERES Working Groups:

- Instrument: Kory Priestley
- ERBElike: Takmeng Wong
- Clouds: Pat Minnis
- Inversion: Norman Loeb
- SOFA: David Kratz
- SARB: Tom Charlock
- TISA: David Doelling
- FLASHFlux: Paul Stackhouse & David Kratz
- Data Management: Jonathon Gleason
- ASDC: John Kusterer

CERES Flight Schedule

Enabling Climate Data Record Continuity



CERES Terra/Aqua News

Science Team Meetings:

- Spring 2010: April 27-29. Marriott at City Center, Newport News.

Special Sessions at Conferences:

- Fall AGU 2009: Terra at 10 session, December 16

AMS Radiation Conference (Joint with Cloud Physics):

- June 28 – July 2, 2010. Portland OR

CERES Reviews:

Senior Review proposals: Terra and Aqua (March 2009).

=> Determines CERES Terra/Aqua budgets for next 2 years.

=> Optimal budget awarded. Additional funding will be used to improve CERES data ordering tools at ASDC and optimizing processing procedures to increase data product throughput.

CERES Terra/Aqua News (cont'd)

Awards:

- Center Award to CERES FM5 Team: "For dedication and teamwork, resulting in delivery of a fully tested and calibrated CERES instrument, within budget and on schedule, to ensure that CERES FM5 can be launched."
- William T. Pecora Award (2009): "Recognizing outstanding contributions by individuals or groups toward understanding the Earth by means of remote sensing."
- Pat Minnis named AGU and AMS Fellow.

Other News:

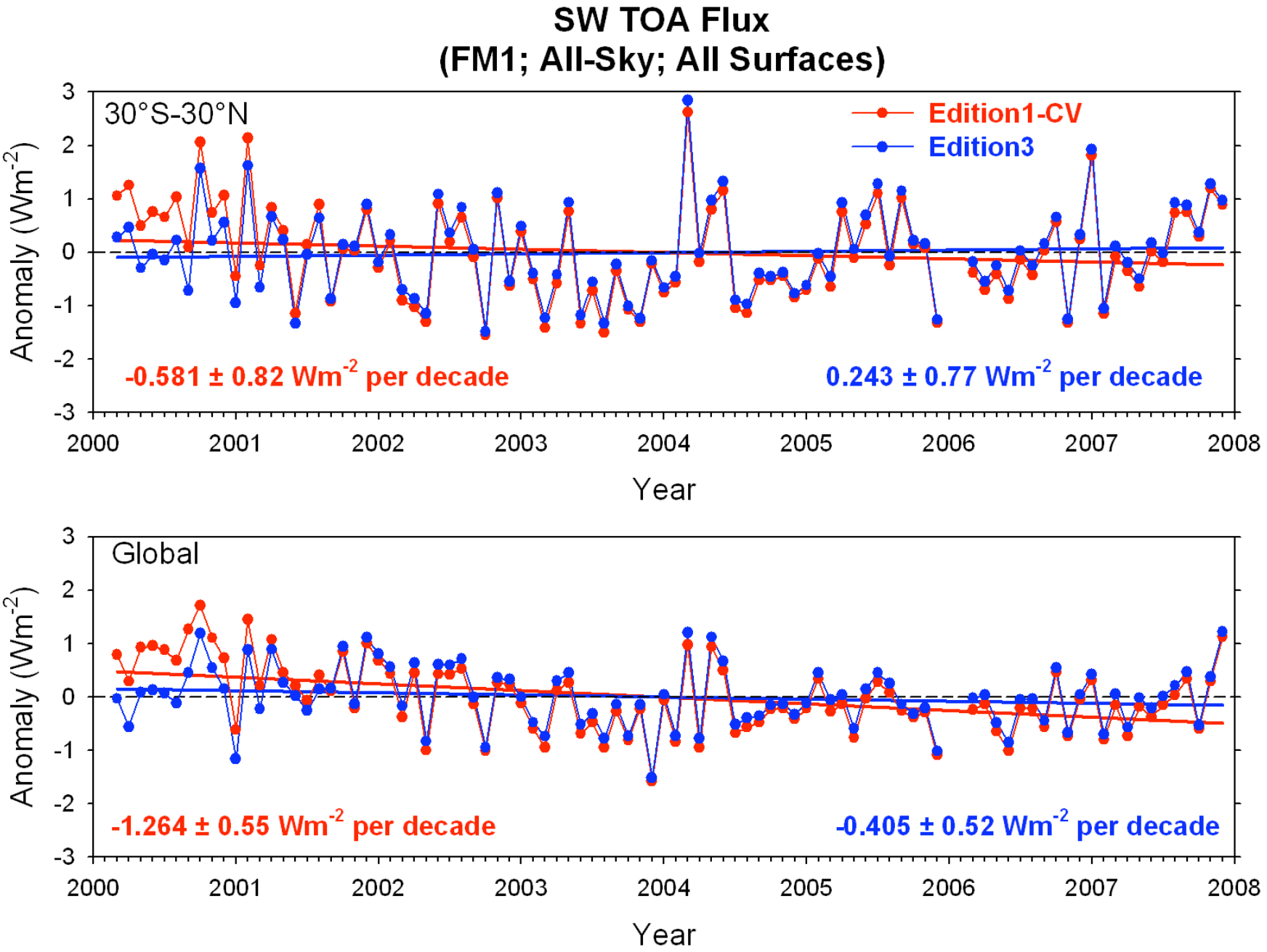
- CERES will be featured on NPRs "Earth and Sky" radio program. Other instruments on Aqua spacecraft will also be featured.
- CERES Ocean Validation Experiment (COVE) Site:
  - Operates instruments from BSRN, AERONET, MPL
  - US Coast Guard wants to excess or auction off the Chesapeake Lighthouse platform.
  - It is not feasible for CERES (NASA) to take over platform (too expensive to maintain).
  - Currently exploring other arrangements/options.

Early Edition 3 Quality Level-3 Data Product Release

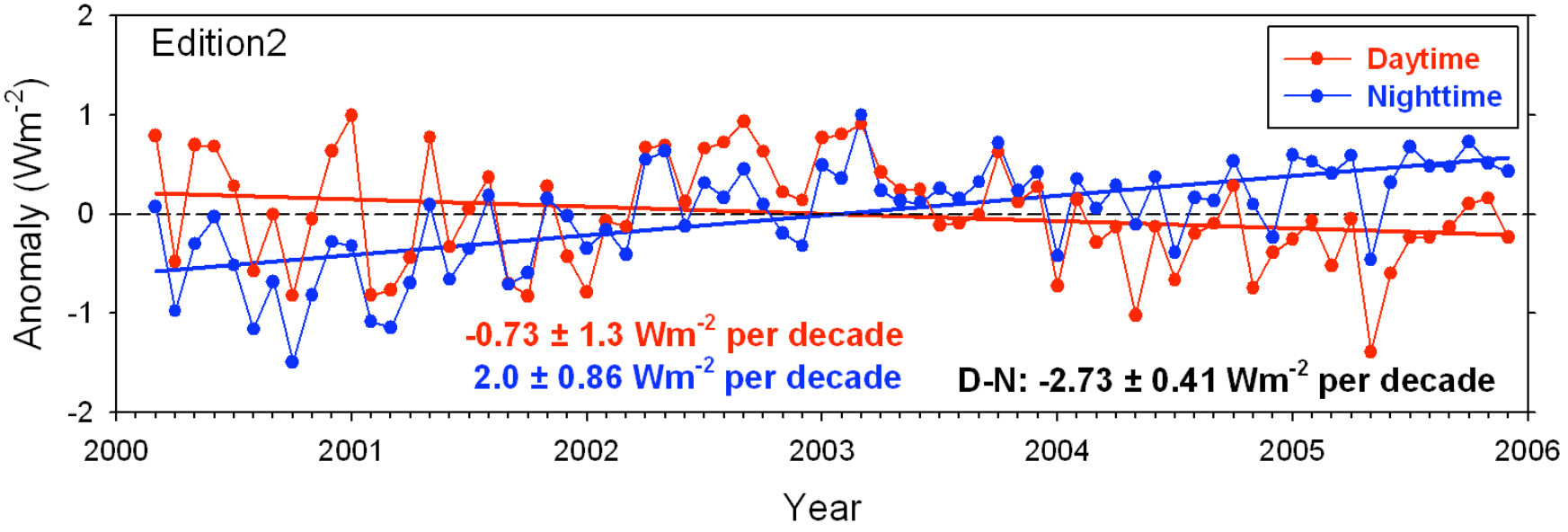
- Working on an early release of a Level-3 CERES Terra data product produced off-line at the SCF and distributed at ASDC.
- New CERES data product is a hybrid of Edition2 and Edition3.
  -> Uses best-quality Edition3 instrument radiances and Ed2 cloud properties to generate L3 TOA fluxes as quickly as possible through end of 2008.
  ->Saves approximately 2 years of time before any of the official Edition-3 L3 CERES data products are released.
  ->Will consist of a small subset of SRBAVG cloud and TOA radiation parameters.
  -> Will be continued when full Editon3 data products are released and available through ASDC subsetter data ordering tool (Doelling presentation).

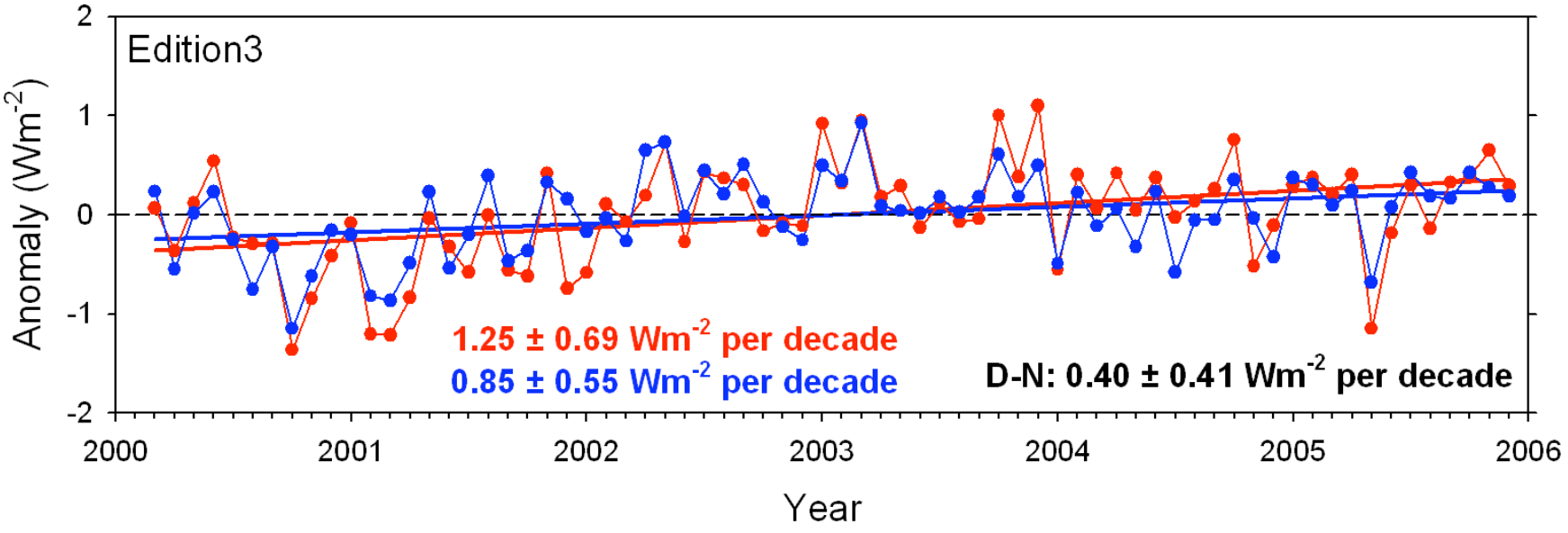
Proposed Name: **CERES Terra SSF-Grid-Monthly-lite-Edition 2.5**

Anticipated Release: Early 2010 (Terra)


SW TOA Flux
(FM1; All-Sky; All Surfaces)
30°S-30°N
Edition1-CV
Edition3
-0.581 ± 0.82 Wm-2 per decade
0.243 ± 0.77 Wm-2 per decade
Anomaly (Wm-2)
Year
Global
-1.264 ± 0.55 Wm-2 per decade
-0.405 ± 0.52 Wm-2 per decade
Anomaly (Wm-2)
Year

Global Daytime and Nighttime LW TOA Flux
(FM1; All-Sky; All Surfaces)





CERES Recent History/Background

- NASA originally planned to build additional CERES copies and launch a series of three spacecraft separated by 5 years in both morning and afternoon orbits.
- When NPOESS decided to build and fly copies of CERES on their afternoon satellites, NASA cancelled future radiation budget sensor builds.
- NPOESS had planned to fly the remaining CERES instrument (FM-5) on the first NPOESS 1:30 pm orbit in 2010, and additional copies in 2015 and beyond.
- The cost growths in NPOESS were sufficiently large (>25%) that the so-called "Nunn-McCurdy" process of the Department of Defense (DoD) was initiated.
- The review resulted in significant scale-back of climate capabilities (e.g., OMPS Limb, TSIS, ERBS, ALT, APS).
- New plan was to fly the last copy of CERES (FM-5) on NPOESS C1 in 2013.

- Joint NASA/NOAA white paper submitted to OSTP Jan 2007 recommended:
  - Moving CERES FM-5 to NPP mission in 2010.
  - Building additional CERES copies to add to NPOESS platforms in 2013 and 2019. Would fly with VIIRS imager for CERES-like data products.
- NASA agreed to move CERES FM-5 from NPOESS C1 to NPP in late 2007. Launch has since slipped to Jan 2011.
- NOAA's FY 2009 Passback included $74M to mitigate the loss of climate sensors on NPOESS and to provide long term Climate Data records.
  - Specifically targeted for most cost effective options for launching Clouds and Earth's Radiant Energy System (CERES) and Total Solar Irradiance Sensor (TSIS), as well as support for initial work on Climate Data Records.

CERES FM5 on NPP

- CERES FM5 is a NASA sensor manufactured by Northrop Grumman (NG), and provided to the NPP by NASA.
- Instrument Operations, Data Processing and Science provided by NASA LaRC.
- Congratulations to FM5 team: January 2008 ATP to November 2008 instrument delivery. On cost and on schedule!
- CERES data management group also deserves credit for getting code ready (code conversion/VIIRS subsetting); Working in a much more complex environment:
- **Data flow**: NPP => Ground Station => NPOESS IDPS =>

  (i) NOAA CLASS archive; (ii) GSFC SDS => GSFC PEATE => LaRC ASDC => CERES Team

NPOESS Preparatory Project (NPP)

- Comprised of 5 instruments:

Visible/Infrared Imager/Radiometer Suite (**VIIRS**)

Cross-track Infrared Sounder (**CrIS**)

Clouds and the Earth's Radiant Energy System (**CERES**)

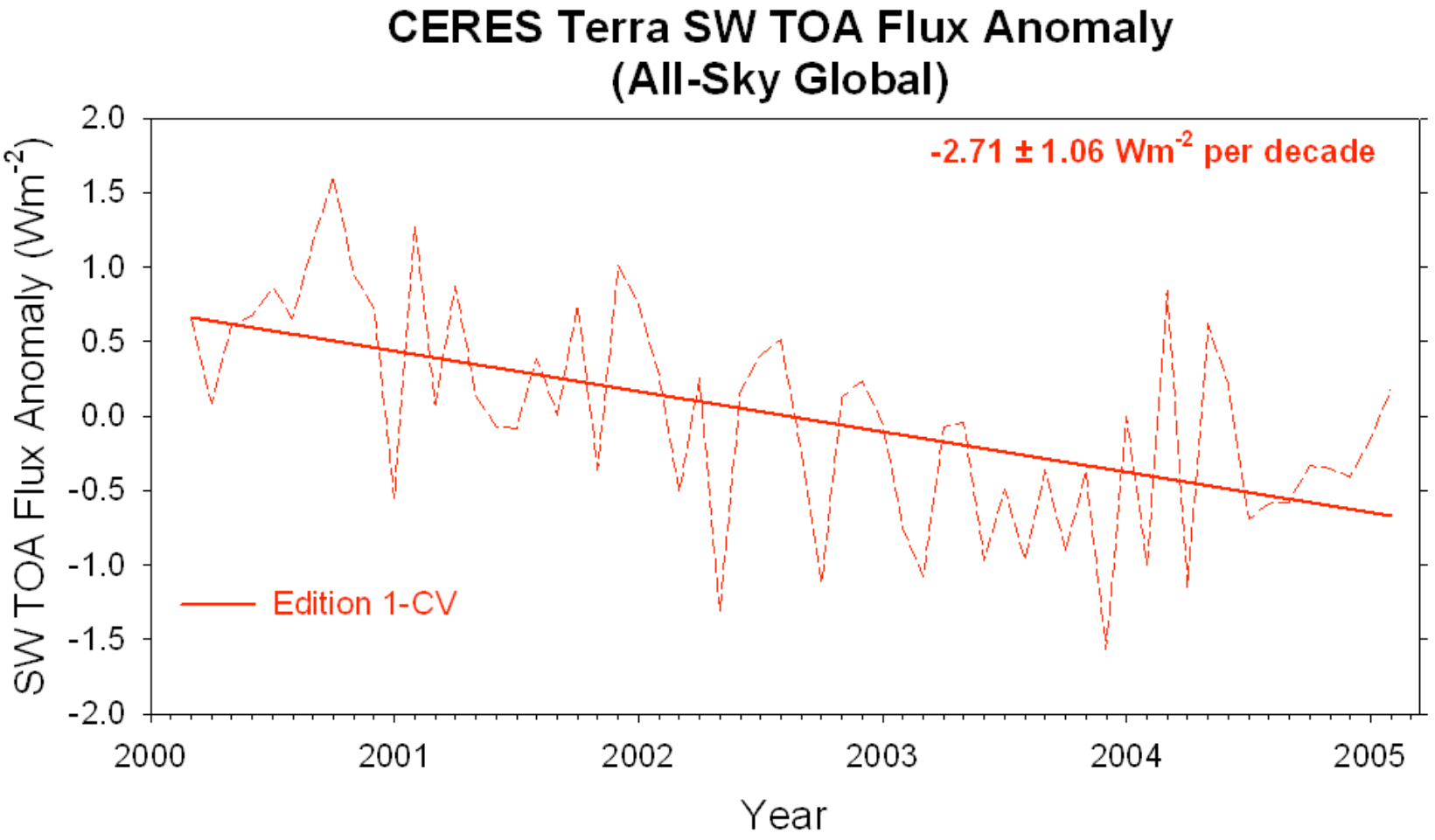
Ozone Mapping Profiler Suite (**OMPS**)

Advanced Technology Microwave Sounder (**ATMS**)

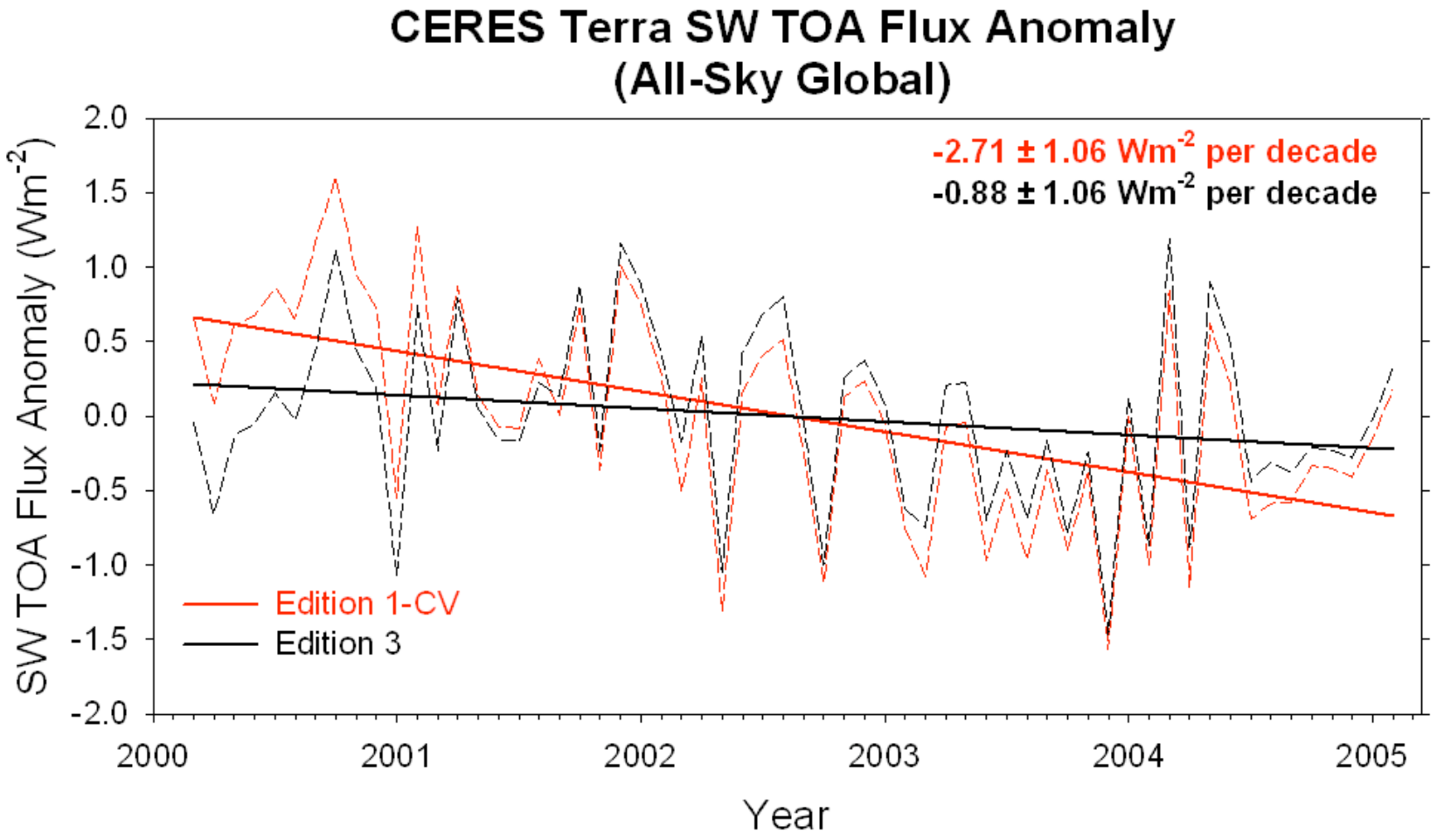
- All of the NASA elements (i.e., launch vehicle, spacecraft, CERES, ATMS) are on schedule.
- Significant delays with the NGST/NPOESS-led procurement of the VIIRS sensor.
- VIIRS Update:
  - Ambient Electro-Magnetic Interference Testing (EMI) completed (Nov '08)
  - Vibration testing completed (Feb '09)
  - Thermal Vacuum testing completed (Sept '09).
  - Pre-Ship Review: December 16-18, 2009.
- CrIS: Scheduled on-the-hook date June 2010
- Official NPP launch: January 2011 (original launch date: mid-2006).

CERES FM6 on NPOESS C1

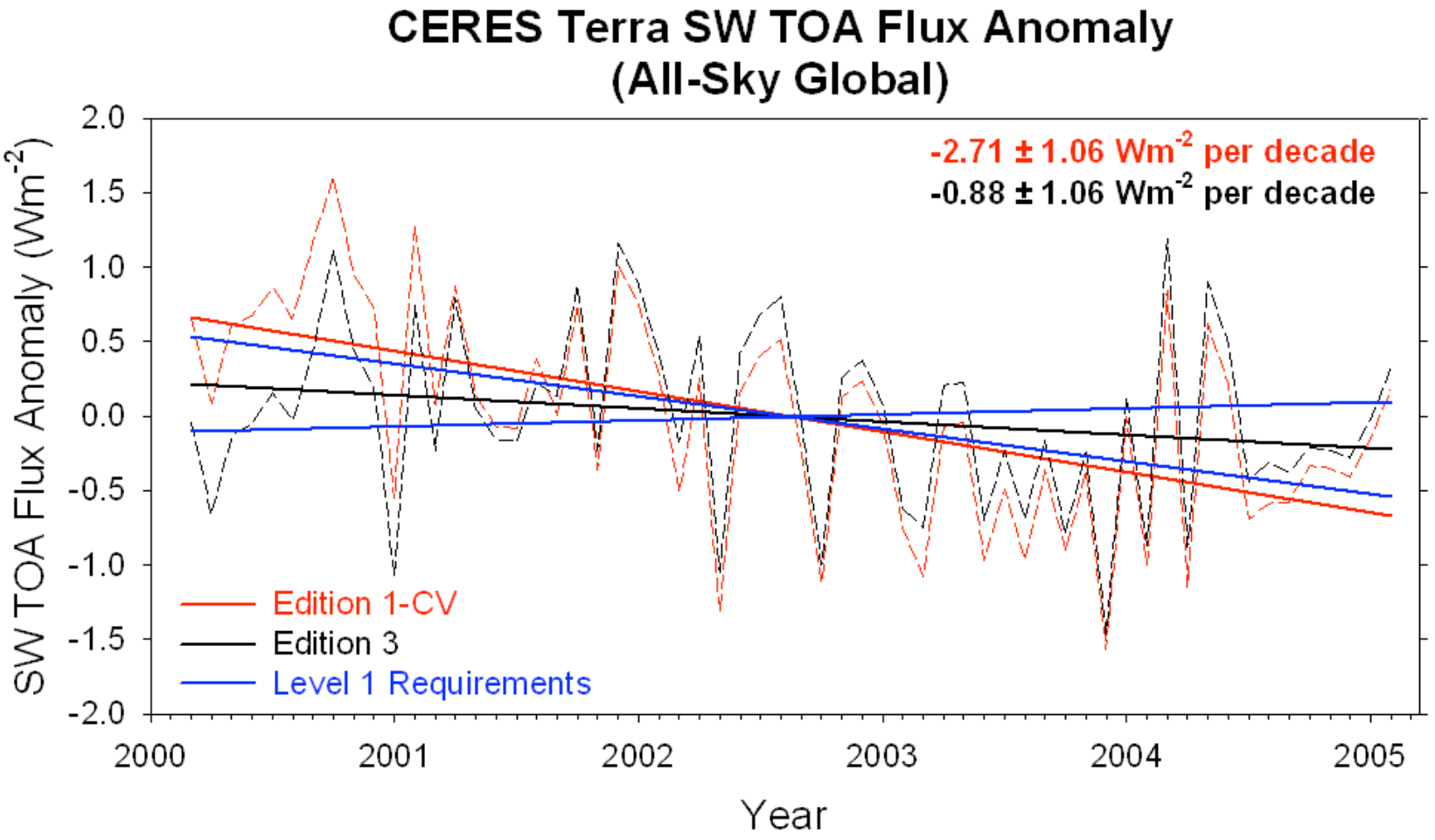
- CERES FM6 is a government-furnished sensor manufactured by Northrop Grumman (NG), and provided to the NPOESS program by NOAA/NASA.
- Northrop Grumman Aerospace System (NGAS) working under contract to NASA LaRC.
- Build-to-Print and from spare parts.
- Minor modifications to accommodate NPOESS C1 interface and improve calibration.
- Start Date: May 2009; Delivery Date: July 2012; Launch in 2014.
- **Most important calibration improvements recommended by NASA CERES Team (SWICS+MAM photodiode) not implemented.**



- Without any corrections for instrument changes in-orbit, the global mean reflected SW TOA flux decrease exceeds natural variability at 95% confidence level.



- Without any corrections for instrument changes in-orbit, the global mean reflected SW TOA flux decrease exceeds natural variability at 95% confidence level.
- With 2 CERES instruments on Terra, a correction for on-orbit contamination is possible, thereby removing instrument artifacts from the record.



- Without any corrections for instrument changes in-orbit, the global mean reflected SW TOA flux decrease exceeds natural variability at 95% confidence level.
- With 2 CERES instruments on Terra, a correction for on-orbit contamination is possible, thereby removing instrument artifacts from the record.
- NPOESS operational scenarios fly one CERES per spacecraft. Without improvements to onboard calibration sources, Level-1 requirements will not be met.

CERES Climate Data Records

- Continuing a CDR requires a 'cradle-to-grave' approach. The science team must have responsibility for the entire program lifecycle: instrument design, fabrication, assembly, test, spacecraft integration, post-launch instrument operational tasking, calibration, data processing and validation.
- These activities have historically have been provided by NASA LaRC for CERES (FM1-FM5 on EOS & NPP).
- For FM6 (a NOAA instrument), NASA and NOAA roles/responsibilities beyond the instrument build have yet to be defined.
- Highest priority should be to continue to ensure the highest quality possible in the most efficient and cost-effective manner.

-> Leverage off of existing structures: Terra/Aqua/NPP structure for mission operations, science, data management, operational data processing (ASDC), etc.

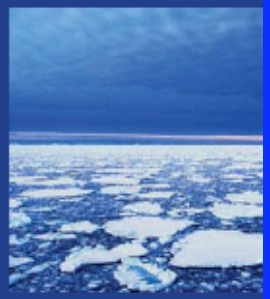
- There is no straightforward and inexpensive way to transition CDRs like CERES (complex from data fusion, but at climate accuracy).

-> The decades of expertise used to validate, understand, quality control, and continuously fix input data sets cannot easily be bought or transplanted as a set of documents and software.

A VISION FOR CLIMATE SERVICES IN NOAA










This report was drafted by a select team of NOAA scientists and related experts from across the Agency. The team unanimously presents these goals and principles for consideration by NOAA along with other inputs to the development of its overall climate services strategy.

A-Train Update

- Glory launch delayed to October 2010
- CALIPSO passed 1000 day-mark in orbit on January 23, 2009. Successfully transitioned to backup laser on March 9, 2009.
- New merged CALIPSO-CloudSat-CERES-MODIS (C3M) dataset: 4 months released (see S. Kato Co-I presentation).

Decadal Survey

- NASA still committed to implementing DS. Tier 1 Missions:
  - Climate Absolute Radiance and Refractivity Observatory (CLARREO)
  - Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI)
  - Soil Moisture Active-Passive (SMAP)
  - Ice, Cloud, and Land Elevation Satellite (ICESat-II)

Decadal Survey defines NASA CLARREO

- **Societal Benefits:**

  Enable knowledgeable policy decisions based on internationally acknowledged climate measurements and models through:

  - *Observation of high accuracy long-term climate change trends*
  - *Use the long term climate change observations to test and improve climate forecasts.*

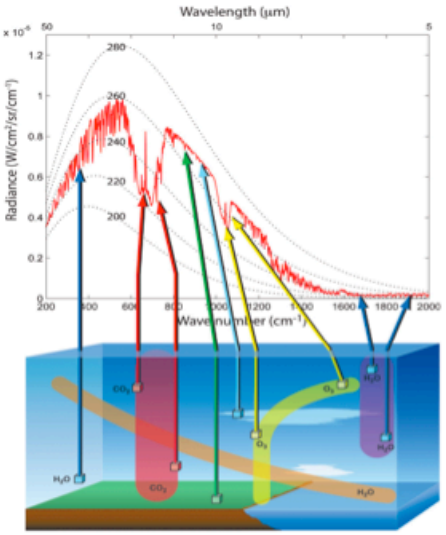
- **Science Objectives: Climate Response, Forcing, Feedback**

  - Infrared spectra to infer temperature and water vapor feedbacks, cloud feedbacks, and decadal change of temperature profiles, water vapor profiles, clouds, and greenhouse gas radiative effects
  - GNSS-RO to infer decadal change of temperature profiles
  - Solar reflected spectra to infer cloud feedbacks, snow/ice albedo feedbacks, and decadal change of clouds, radiative fluxes, aerosols, snow cover, sea ice, land use
  - Serve as an in-orbit calibration standard for broadband CERES, and operational sounders (CrIS, IASI)

Summary of Required CLARREO Measurements

Infrared

– *Measures the infrared radiance spectra of the Earth and its atmosphere with systematic error that corresponds to < 0.1 K brightness temperature radiometric calibration uncertainty*

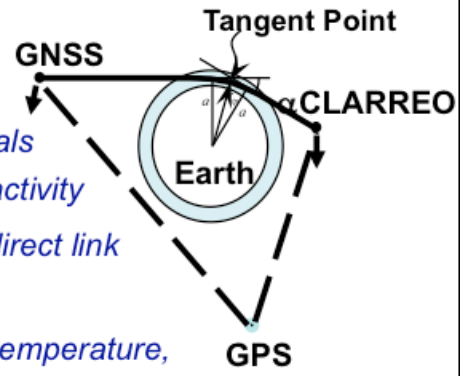


– *Calibration accuracy attained by rigorous on-orbit verification system*

– *Provides critical information to address cloud, water vapor, and lapse rate feedbacks and responses*

– *Provides reference calibration for operational sounders*

GNSS-RO



– *Radio occultation of GNSS signals used to derive atmospheric refractivity*

– *Accuracy is attained through a direct link to the SI standard of time*

– *Provides critical information on temperature, pressure, and humidity profiles to address cloud, water vapor, and lapse rate feedbacks and responses*

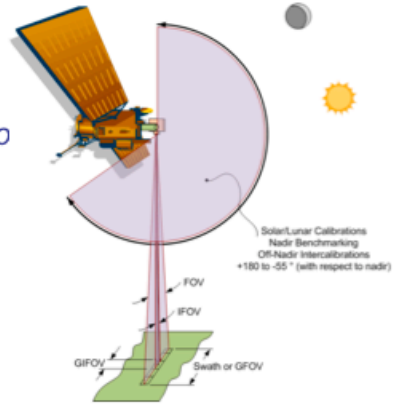
Reflected Solar

– *Measures the solar spectral reflectance of the Earth and its atmosphere relative to the solar irradiance spectrum*

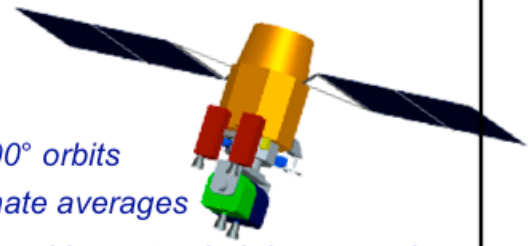
– *Calibration accuracy attained using the Sun as a calibration reference standard*

– *Provides necessary information for reducing uncertainties in clouud feedback, surface albedo feedback, and land use change radiative forcing*

– *Provides reference calibration for operational sensors*



Mission Configuration



– *Two identical spacecraft in 90° orbits provide unbiased global climate averages*

– *5-year expendable lifetime provides extended data record sampling required to separate trends from natural variability*

CLARREO Formulation Status

CLARREO Science is Defined

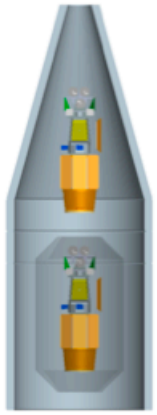
- CLARREO provides observations of high accuracy long-term climate change trends with the improved accuracies and careful sampling needed to characterize the forcings, responses and feedbacks of Earth's climate.
  - *Focused on decadal-scale trends to test and improve climate forecasts*
  - *Requirements set by the top climate change uncertainties identified by IPCC*
  - *Robust dual implementation strategy using CLARREO-only benchmark records and reference intercalibration*
- Draft Level 1 Requirements delivered and in review at HQ

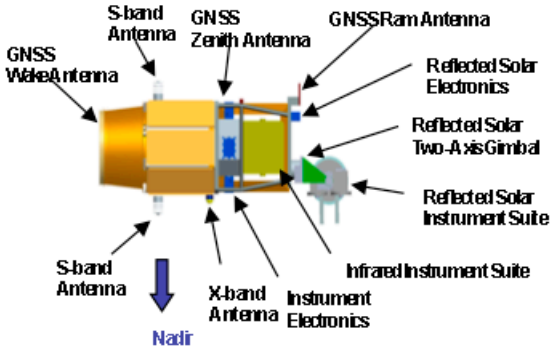
Major Project Accomplishments

- Two comprehensive mission design cycles completed
  - *Mission architecture is technically robust with mission elements based on heritage designs allowing launch in 2016.*
- Measurement requirements have led to successful instrument conceptual designs
  - *Three CLARREO instruments are extensively based on flight-proven techniques*
  - *Concepts vetted during 3 instrument design lab sessions*
- Langley / Goddard partnership formally established
- Independent Concept Validation
  - *Spacecraft RFI validated our in-house observatory power and mass estimates*
  - *Independent instrument error budget analyses completed*
- Careful, rigorous cost estimates at this phase providing high confidence against growth.

CLARREO Mission Concept Meets All Science Objectives

- Two identical observatories co-manifested on an EELV
- Two orthogonal 609 km polar orbits (90° inclination)
- 3-year design life with spacecraft consumables to extend to a 5-year mission
- Instrument payload
  - *IR FTS spectrometer*
  - *Reflected solar spectrometer suite*
  - *GNSS RO*
  - *Extensive on-orbit calibration verification*





Bottom Line

- *The CLARREO team has developed a feasible and credible mission concept to meet the science objectives*
- *The project is on schedule to meet the February 2010 MCR Date*